Our Ref.: 2380-589
P14203US2

U.S. PATENT APPLICATION

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Invention: CONTROLLING TRANSMISSION OF CELL INFORMATION BETWEEN CONTROL NODES IN RADIO ACCESS NETWORK

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SPECIFICATION

CONTROLLING TRANSMISSION OF CELL INFORMATION BETWEEN CONTROL NODES IN RADIO ACCESS NETWORK

BACKGROUND

This application claims the priority and benefit of United States Provisional Patent Application No. 60/260,901, filed January 12, 2000, which is incorporated herein by reference in its entirety.

1. FIELD OF THE INVENTION

The present invention pertains to telecommunications, and particularly to the transmission of cell information between control nodes of a radio access network.

2. RELATED ART AND OTHER CONSIDERATIONS

In a typical cellular radio system, mobile user equipment units (UEs) communicate via a radio access network (RAN) to one or more core networks. The user equipment units (UEs) can be mobile stations such as mobile telephones ("cellular" telephones) and laptops with mobile termination, and thus can be, for example, portable, pocket, hand-held, computer-included, or car-mounted mobile devices which communicate voice and/or data with radio access network.

The radio access network (RAN) covers a geographical area which is divided into cell areas, with each cell area being served by a base station. A cell is a geographical area where radio coverage is provided by the radio base station equipment at a base station site. Each cell is identified by a unique identity, which is broadcast in the cell. The base stations communicate over the air interface (e.g., radio frequencies) with the user equipment units (UE) within range of the base stations. In the radio access network, several base stations are typically connected (e.g., by landlines or

microwave) to a radio network controller (RNC). The radio network controller, also sometimes termed a base station controller (BSC), supervises and coordinates various activities of the plural base stations connected thereto. The radio network controllers are typically connected to one or more core networks.

One example of a radio access network is the Universal Mobile Telecommunications (UMTS) Terrestrial Radio Access Network (UTRAN). The UTRAN is a third generation system which is in some respects builds upon the radio access technology known as Global System for Mobile communications (GSM) developed in Europe. UTRAN is essentially a wideband code division multiple access (W-CDMA) system.

As those skilled in the art appreciate, in W-CDMA technology a common frequency band allows simultaneous communication between a user equipment unit (UE) and plural base stations. Signals occupying the common frequency band are discriminated at the receiving station through spread spectrum CDMA waveform properties based on the use of a high speed, pseudo-noise (PN) code. These high speed PN codes are used to modulate signals transmitted from the base stations and the user equipment units (UEs). Transmitter stations using different PN codes (or a PN code offset in time) produce signals that can be separately demodulated at a receiving station. The high speed PN modulation also allows the receiving station to advantageously generate a received signal from a single transmitting station by combining several distinct propagation paths of the transmitted signal. In CDMA, therefore, a user equipment unit (UE) need not switch frequency when handoff of a connection is made from one cell to another. As a result, a destination cell can support a connection to a user equipment unit (UE) at the same time the origination cell continues to service the connection. Since the user equipment unit (UE) is always communicating through at least one cell during handover, there is no disruption to the call. Hence, the term "soft handover." In contrast to hard handover, soft handover is a "make-before-break" switching operation.

There are several interfaces of interest in the UTRAN. The interface between the radio network controllers (RNCs) and the core network(s) is termed the "Iu" interface. The interface between a radio network controller (RNC) and its base stations (BSs) is termed the "Iub" interface. The interface between the user equipment unit

(UE) and the base stations is known as the "air interface" or the "radio interface". In some instances, a connection involves both a Serving or Source RNC (SRNC) and a target or drift RNC (DRNC), with the SRNC controlling the connection but with one or more diversity legs of the connection being handling by the DRNC. The interface between a SRNC and a DRNC is termed the "Iur" interface. An understanding of the functions performed by the SRNC, the DRNC, and the type of information exchanged therebetween can be gleaned from one or more of the following (all of which are incorporated herein by reference) United States Patent Application Serial No. 09/035,821 filed March 6, 1998, entitled "Telecommunications Inter-Exchange Measurement Transfer"; United States Patent Application Serial No. 09/035,788 filed March 6, 1998, entitled "Telecommunications Inter-Exchange Congestion Control"; United States Patent Application Serial No. 09/638,858 filed August 15, 2000, entitled "Transfer of Overlapping Routing Area Control Information In A Radio Access Network"; and United States Patent Application Serial No. 09/543,536 filed April 5, 2000, entitled "Relocation of Serving Radio Network Controller With Signaling of Linking of Dedicated Transport Channels".

When it is appropriate to establish a new leg of a connection controlled by a SRNC through a base station controlled by a DRNC, the SRNC typically requests that the DRNC allocate resources (e.g., radio link resources) for the new leg of the connection in the cell served by the base station which will host the new leg. The Third Generation Partnership Project (3GPP), which has undertaken to evolve further the UTRAN and GSM-based radio access network technologies, proposes in its specifications that the DRNC transmit or transfer cell information for each cell where radio resources are being established. See, e.g., 3G TS 25.423, v.3.4.0: UTRAN Iur Interface RNSAP Signaling (ftp://ftp.3gpp.org/Specs/2000-12R/R1999/25 series/25423-340.zip). The transfer of cell information as proposed by the 3GPP means that, if an SRNC requests resources in a particular cell for many users (UEs), the SRNC will in response receive the same cell information many times (once for each user) from the DRNC. Such redundancy is inefficient and consume unnecessary bandwidth in the signaling network and causes additional signaling delay.

What is needed, therefore, and an object of the present invention, is an efficient and economical technique for communicating cell information between radio network control nodes of a radio access network.

BRIEF SUMMARY OF THE INVENTION

A telecommunications network simplifies data flow and signaling by having a second control node of a radio access network transmit cell information to a first control node only when the cell information is not already known by the first control node. The invention is facilitated by a cell configuration generation index (CCGI). The cell configuration generation index (CCGI) represents a set of cell information parameters deemed current for a specified cell by a control node. In one example embodiment, the cell configuration generation index (CCGI) is a counter whose value is changed when configuration data of the specified cell is changed.

In one example scenario, a cell identifier for the specified cell and the first control node's CCGI for the specified cell are included in a request message sent from the first control node to the second control node. If the second control node determines that the first control node's CCGI for the specified cell is current, no cell information for the specified cell need be sent by the second control node to the first control node in response. However, if the second control node determines that the first control node's CCGI for the specified cell is not current, the second control node includes in a response message both (1) the cell information deemed current by the second control node for the specified cell; and (2) the second control node's CCGI (which is current and accurate) for the specified cell.

In another example scenario, if the request message sent from the first control node to the second control node contains only a cell identifier for the specified cell and not a CCGI for the specified cell, a response message sent from the second control node to the first control node includes both (1) the cell information deemed current by the second control node for the specified cell; and (2) the second control node's CCGI (which is current and accurate) for the specified cell.

In one mode of the invention, the cell information includes a set of cell information parameters characterizing the specified cell served by a base station controlled by the second control node. In another mode of the invention, the cell information can optionally include a set of cell information parameters which characterizes at least one cell which neighbors the specified cell (and preferably all the cells which neighbor the specified cell).

The first control node and the second control node can, in illustrated embodiments, both be radio network control nodes of a radio access network. More particularly, in one example implementation the first control node is a Serving Radio Network Control (SRNC) node and the second control node is a Drift Radio Network Control (DRNC) node. In the context of this example implementation, the request message sent by the first control node to the second control node can be a message which requests that the second control node allocate resources in the specified cell for a connection controlled by the first control node (e.g., a radio link setup request message or a radio link addition request message). The response message can be of the nature of a radio link setup response message or a radio link addition response message. The request and response messages of the present invention are not, however, limited to or necessarily confined to resource allocation, as the request message can instead take the form of a status or update request or the like for ascertaining the actual current cell information for the specified cell [and/or optionally the neighboring cell(s)].

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1 is diagrammatic view of example mobile communications system in which the present invention may be advantageously employed.

Fig. 1A is a diagrammatic view illustrating a setup of a connection with a user equipment unit (UE).

Fig. 1B is a diagrammatic view illustrating transit of the user equipment unit (UE) of Fig. 1A and setup of further connection legs therefor.

Fig. 1C is a diagrammatic view illustrating further transit of the user equipment unit (UE) of Fig. 1B and setup of yet further connection legs therefor in a cell controlled by a Drift RNC.

Fig. 2 is a diagrammatic view of an example embodiment showing, e.g., components of two radio network control nodes involved in the present invention.

Fig. 2A - Fig. 2D are diagrammatic views showing, e.g., differing generic scenarios of message interchange between two radio network control nodes in accordance with the present invention.

Fig. 3 is diagrammatic view showing, e.g., messages involved in the scenarios of Fig. 2A - Fig. 2D taking the form of messages involved in a radio link setup procedure.

Fig. 4 is diagrammatic view showing, e.g., messages involved in the scenarios of Fig. 2A - Fig. 2D taking the form of messages involved in a radio link addition procedure.

Fig. 5 is diagrammatic view showing, e.g., messages involved in the scenarios of Fig. 2A - Fig. 2D taking the form of messages involved in a cell information retrieval procedure.

Fig. 6, Fig. 6A(1), Fig. 6A(2), Fig. 6B(1), Fig. 6B(2), and Fig. 6C are diagrammatic views showing messages involved with a neighboring cell mode of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

The present invention is described in the non-limiting, example context of a universal mobile telecommunications (UMTS) 10 shown in Fig. 1. A representative, connection-oriented, external core network, shown as a cloud 12 may be for example the Public Switched Telephone Network (PSTN) and/or the Integrated Services Digital

Network (ISDN). A representative, connectionless-oriented external core network shown as a cloud 14, may be for example the Internet. Both core networks are coupled to corresponding service nodes 16. The PSTN/ISDN connection-oriented network 12 is connected to a connection-oriented service node shown as a Mobile Switching Center (MSC) node 18 that provides circuit-switched services. The Internet connectionless-oriented network 14 is connected to a General Packet Radio Service (GPRS) node 20 tailored to provide packet-switched type services which is sometimes referred to as the serving GPRS service node (SGSN).

Each of the core network service nodes 18 and 20 connects to a UMTS Terrestrial Radio Access Network (UTRAN) 24 over a radio access network (RAN) interface referred to as the Iu interface. UTRAN 24 includes one or more radio network controllers (RNCs) 26 and one or more base stations (BS) 28. . For sake of simplicity, the UTRAN 24 of Fig. 1 is shown with only two RNC nodes, particularly RNC 26_1 and RNC26_2. Each RNC 26 is connected to one or more base stations (BS) 28. For example, and again for sake of simplicity, two base station nodes are shown connected to each RNC 26. In this regard, RNC 26_1 serves base station 28_{1-1}, base station 28_{1-2}, and base station 28_{1-3}, while RNC 26_2 serves base station 28_{2-1} base station 28_{2-2}, and base station 28_{2-3}. It will be appreciated that a different number of base stations can be served by each RNC, and that RNCs need not serve the same number of base stations. Moreover, Fig. 1 shows that an RNC can be connected over an Iur interface to one or more other RNCs in the UTRAN 24.

A user equipment unit (UE), such as user equipment unit (UE) 30 shown in Fig. 1, communicates with one or more base stations (BS) 28 over a radio or air interface 32. Each of the radio interface 32, the Iu interface, the Iub interface, and the Iur interface are shown by dash-dotted lines in Fig. 1. Preferably, radio access is based upon wideband, Code Division Multiple Access (WCDMA) with individual radio channels allocated using CDMA spreading codes. Of course, other access methods may be employed. WCDMA provides wide bandwidth for multimedia services and other high transmission rate demands as well as robust features like diversity handoff and RAKE receivers to ensure high quality. Each user mobile station or equipment unit (UE) 30 is assigned its own scrambling code in order for a base station 28 to identify transmissions from that particular user equipment unit (UE) as well as for the user equipment unit

(UE) to identify transmissions from the base station intended for that user equipment unit (UE) from all of the other transmissions and noise present in the same area.

Different types of control channels may exist between one of the base stations 28 and user equipment units (UEs) 30. For example, in the forward or downlink direction, there are several types of broadcast channels including a general broadcast channel (BCH), a paging channel (PCH), a common pilot channel (CPICH), and a forward access channel (FACH) for providing various other types of control messages to user equipment units (UEs). In the reverse or uplink direction, a random access channel (RACH) is employed by user equipment units (UEs) whenever access is desired to perform location registration, call origination, page response, and other types of access operations. The random access channel (RACH) is also used for carrying certain user data, e.g., best effort packet data for, e.g., web browser applications. Traffic channels (TCH) may be allocated to carry substantive call communications with a user equipment unit (UE).

When a connection between the radio access network (RAN) and user equipment unit (UE) is being established, the radio access network (RAN) decides which RNC is to be the serving RNC (SRNC) and, if needed, which RNC is to be a drift RNC (DRNC). Normally, the RNC that controls the cell where the user equipment unit (UE) is located when the connection is first established is initially selected as the serving RNC (SRNC) . As the user equipment unit (UE) moves, the connection is maintained by establishing radio communication branches or legs via new cells, possibly cells controlled by other RNCs. Those other RNCs become drift RNCs (DRNC) for RAN-UE connection.

To illustrate the foregoing, and as a prelude to an explanation of the present invention, reference is made to the situation shown in Fig. 1A. Fig. 1A shows an example of RNC role assignment for user equipment unit (UE) 30 at initial setup of a connection involving user equipment unit (UE) 30. In Fig. 1A, radio network controller (RNC) 26_1 acts as the serving RNC (SRNC) for the connection with user equipment unit (UE) 30, since user equipment unit (UE) 30 is in the cell controlled by base station (BS) 28_{1-1} when the connection is first established. An initial leg of the connection with user equipment unit (UE) 30 in Fig. 1A is shown by the broken line 36_{1-1} (which extends from core network 16, through radio network controller (RNC) 26_1, and base

station (BS) 28_{1-1} to user equipment unit (UE) 30). While it is assumed that the connection with user equipment unit (UE) 30 has a user connected to the core network as the second party, it should be understood that the second party could instead be another user equipment unit (UE), e.g., a mobile telephone.

Suppose that user equipment unit (UE) 30 travels in the rightward direction indicated by arrow 34 to the location shown in Fig. 1B. At the location of user equipment unit (UE) 30 it so happens that the connection involving user equipment unit (UE) 30 now has two legs. The initial leg through base station (BS) 28_{1-1} is no longer viable and has been removed. One present leg of the connection, shown by the broken line 36_{1-2}, is through base station (BS) 28_{1-2}. Another present leg of the connection, shown by the broken line 36_{1-3}, is through base station (BS) 28_{1-3}. When it became apparent that each of legs depicted by broken line 36_{1-2}, and broken line 36_{1-3} should be established, the SRNC 26_1 allocated radio link resources for each leg in the respective cells.

Fig. 1C shows the user equipment unit (UE) 30 traveling even further in the rightward direction indicated by arrow 34. With the location of user equipment unit (UE) 30 as shown in Fig. 1C, a further leg of the connection through base station (BS) 28_{2-1} (indicated by the broken line 36_{2-1}) is appropriate. Notably, the base station (BS) 28_{2-1} is controlled by RNC 26_2, which will function as a Drift RNC (DRNC) for the connection (which is controlled by SRNC 26_1). In order to establish the leg of the connection through base station (BS) 28_{2-1}, the SRNC 26_1 must request the DRNC 26_2 to allocate radio link resources for the connection leg (e.g., the leg indicated by the broken line 36_{2-1}).

The request from a SRNC for a DRNC to allocate radio link resources is just one example event in which cell information (about a cell served by a base station controlled by the DRNC) is communicated over the Iur interface (e.g., from the DRNC to the SRNC). As used herein, "cell information" for a certain cell refers to a set of cell information parameters which characterize that certain cell.

One example of the type of information parameters included in the set are the information items listed for a FDD cell (e.g., for the FDD mode of UTRAN) in the Radio Link Setup procedure in 99 3GPP TS 25.423 v3.4.0. Those cell information

items are the following: (1) URA Information (UTRAN Registration Area Information); (2) SAI (Service Area Identity); (3) Cell GAI (Cell Geographical Area Information); (4) UTRAN Access Point Position; (5) SSDT Support Indicator (Site Selection Discontinuous Transmission Support Indicator); (6) Closed Loop Timing Adjustment Mode; (7) Primary Scrambling Code; (8) UL UARFCN (Uplink UTRA Absolute Radio Frequency Channel Number); (9) DL UARFCN (Downlink UTRA Absolute Radio Frequency Channel Number); (10) Primary CPICH Power (Primary Common PIlot CHannel Power)

Thus, the cell information comprises a considerable amount of data. In view of the sheer amount of such data, and the bandwidth requirements and signaling delays associated therewith, the present invention pertains to economic and efficient control of the transmission of such cell information between control nodes in a radio access network, e.g., between SRNC and DRNC nodes.

The present invention is facilitated by a cell configuration generation index (CCGI). As explained subsequently, the cell configuration generation index (CCGI) briefly represents the cell information deemed current for a specified cell by a control node. In a generic example scenario illustrated in Fig. 2, the Serving Radio Network Control Node (SRNC) 26_1 and the Drift Radio Network Control Node (DRNC) 26_2 have respective controllers or managers 100_1, 100_2. Each of the manager 100 has access to a Cell Configuration Generation Index (CCGI) Database, hereinafter referenced as the CCGI database. For example, manager 100_1 of SRNC 26_1 has access to CCGI database 102_1 and managers 100_2 of DRNC 26_2 has access to CCGI database 102_2. The CCGI databases 102 can be situated, for example, at the respective control nodes 26 as shown, or otherwise situated so that information can be communicated between the manager 100 and the CCGI database 102. In the generic embodiment shown in Fig. 2, each of the CCGI databases 102 are conceptualized as a table, each row of the table pertaining to a different cell. As shown in Fig. 2, each row of the table of the CCGI databases 102 has a first field for a cell identifier (cell ID); a third field which has stored therein the cell information for the cell identified in the first field of the row; and, a second field for the cell configuration generation index (CCGI) associated with the cell information in the second field of the row.

Fig. 2 further includes a portion of the cell topography of Fig. 1, showing particularly the cells served by base stations 28_{2-1}, 28_{2-2}, and 28_{2-3}, all of which are controlled by DRNC 26_2. It should be understood that the ensuing example scenarios are not limited to the specific cell or network topography illustrated therein, but that other network and cell configurations are certainly feasible with the present invention.

Fig. 2A shows a scenario in which SRNC 26_1 sends a request message 110_{2A} to DRNC 26_2. The request message 110_{2A} pertains to the cell controlled by base station 28_{2-1}, which for sake of convenience will be referenced also as cell 28_{2-1}. At the time of sending of request message 110_{2A}, for the cell identified as cell 28_{2-1} both the CCGI database 102_1 and the CCGI database 102_2 have the value Y for the CCGI for cell 28_{2-1}. This means that the versions of the cell information for cell 28_{2-1} in the third field of the respective CCGI databases 102 are the same. The parameters included in the request message 110_{2A} of Fig. 2A include the cell identifier and CCGI of the cell which is the subject of request message 110_{2A} (i.e., cell 28_1). Since the SRNC 26_1 thus has the current cell information in the third field of its CCGI databases 102_1 for cell $28_{2-1,}$ the present invention permits the DRNC 26_2 to respond with a simplified response message 112_{2A} as shown in Fig. 2A. In particular, the response message response message 112_{2A} includes the cell identifier for the cell which was the subject of request message 110_{2A} (i.e., cell 28_{2-1}), but advantageously need not contain the cell information for cell 28_{2-1}. Thus, the response message response message 112_{2A} means that the specified cell having the cell identifier is still a valid cell and the actual cell configuration information of the cell corresponds to the received cell configuration generation index (CCGI).

Fig. 2B shows a scenario in which the CCGI database 102_1 of SRNC 26_1 is not current respecting the cell information for the cell which is the subject of request message 110_{2B} (i.e., cell 28_{2-1}). In the scenario shown in Fig. 2B, the actual (e.g., most current) cell information for cell 28_{2-1} stored in the third field of the first row of CCGI database 102_2 in DRNC 26_2 has the CCGI have of "Z" rather than "Y", possibly indicating an update of the cell information for cell 28_{2-1} since the time shown in Fig. 2A. Yet the CCGI database 102_1 accessed by the manager 100_1 of SRNC 26_1 has the older version of the cell information for cell 28_{2-1} which is represented by the value "Y". Thus, when the manager 100_1 of SRNC 26_1 sends request message 110_{2B} to DRNC 26_2, the request message 110_{2B} includes both the cell identifier 28_{2-1} and the CCGI = Y. Upon receipt of request message 110_{2B}, the DRNC 26_2 consults its CCGI database 102_2

and determines that the CCGI database 102_1 of SRNC 26_1 does not have the most current version of the cell information for cell 28_{2-1}. Accordingly, the manager 100_2 of DRNC 26_2 prepares and sends response message 112_{2B} to SRNC 26_1. The response message 112_{2B} includes the cell identifier for cell 28_{2-1}, the cell configuration generation index (CCGI) associated with and representing the cell information deemed current by DRNC 26_2, and the cell information deemed current by DRNC 26_2 (depicted as [CELL INFO[28_{2-1}] in Fig. 2B). Thus, the response message response message 112_{2B} means that the specified cell having the cell identifier is still a valid cell but the actual cell configuration information of the cell does not correspond to the received cell configuration generation index (CCGI), i.e., the cell configuration generation index (CCGI) for the specified cell has changed. The manager 100_1 of SRNC 26_1 can then update its entry in CCGI database 102_1 for cell 28_{2-1}, storing the updated cell configuration generation index (CCGI) value of Z in the second field and the current/updated cell information for cell 28_{2-1} in the third field.

From the foregoing it can be seen that the cell configuration generation index (CCGI) can be formed as a counter or the like. In this regard, cell configuration generation index (CCGI) can be incremented or changed in accordance with a predictable pattern when configuration data of the specified cell is changed. The evolution of values of the cell configuration generation index (CCGI) from "Y" to "Z" for cell 28_{2-1} as described in the transition from Fig. 2A to Fig. 2B. The use of a sequence of letters, numbers, or some other sequential set of values can be used to give the cell configuration generation index (CCGI) this counter or time stamping type of capability.

In the example scenarios generally described above with reference to Fig. 2A - Fig. 2C, a cell identifier for the specified cell and the first control node's CCGI for the specified cell are included in a request message sent from the first control node (SRNC 26_1) to the second control node (DRNC 26_2). If the second control node determines that the first control node's CCGI for the specified cell is current, no cell information for the specified cell need be sent by the second control node to the first control node in response. However, if the second control node determines that the first control node's CCGI for the specified cell is not current, the second control node includes in a response message both (1) the cell information deemed current by the second control

node for the specified cell; and (2) second control node's CCGI (which is current and accurate) for the specified cell.

Fig. 2C shows a scenario in which the CCGI database 102_1 of SRNC 26_1 has no cell information for the cell which is the subject of request message 110_{2B} (i.e., cell 28_{2-1}). In this scenario, the request message 110_{2C} prepared and transmitted by manager 100_1 of SRNC 26_1 to DRNC 26_2 has the cell identifier for the subject cell (cell 28_{2-1}), but not a CCGI value. Therefore, upon receipt the manager 100_2 of DRNC 26_2 recognizes that the CCGI database 102_1 of SRNC 26_1 does not have cell information for cell 28_{2-1}, and accordingly prepares its response message 112_{2C}. The response message 112_{2C} of the Fig. 2C scenario is essentially the same as for the Fig. 2B scenario, including the cell identifier for cell 28_{2-1}, the cell configuration generation index (CCGI) associated with and representing the cell information deemed current by DRNC 26_2, and the cell information deemed current by DRNC 26_2 (depicted as [CELL INFO[28_{2-1}] in Fig. 2C). The manager 100_1 of SRNC 26_1 can then store an entry in CCGI database 102_1 for cell 28_{2-1}, storing the updated cell configuration generation index (CCGI) value of Z in the second field and the current/updated cell information for cell 28_{2-1} in the third field.

Thus, in the example scenario of Fig. 2C, if the request message sent from the first control node to the second control node contains only a cell identifier for the specified cell and not a CCGI for the specified cell, a response message sent from the second control node to the first control node includes both (1) the cell information deemed current by the second control node for the specified cell; and (2) second control node's CCGI (which is current and accurate) for the specified cell.

It can turn out that the SRNC 26_1 issues a request message which includes a cell identifier for a cell unknown to DRNC 26_2. This potential scenario is illustrated in Fig. 2D, wherein the request message 110_{2D} includes a cell identifier for cell 28_{2-4}. Given the particular network topology shown in Fig. 2D, there is no cell 28_{2-4} controlled by DRNC 26_2. Accordingly, DRNC 26_2 prepares and transmits to SRNC 26_1 a response message 112_{2D} which includes an indication that the specified cell (i.e., cell 28_{2-4}) is invalid.

The request message sent from a SRNC such as SRNC 26_1 to a DRNC such as DRNC 26_2 (such as the request messages 110_{2A}, 110_{2B}, and 110_{2C} of Fig. 2A - Fig. 2C, respectively) can take various forms, several examples of which are hereinafter briefly discussed. Fig. 3 shows a situation in which the request message is a radio link setup request message 110_3. A radio link setup request message 110_3 is employed in circumstances such as that shown in Fig. 1C when for the first time a radio link is to be established by the SRNC in a cell controlled by the DRNC. A purpose of the radio link setup request message is to request the DRNC to allocate radio link resources in the new cell for the user equipment unit (UE) whose connection is controlled by the SRNC. In this context, the manager 100_1 of SRNC 26_1 takes the form of UE connection manager $100_{3\text{-}1}$, while the manager 100_2 of DRNC 26_2 takes the form of DRNC cell resource manager $100_{3\text{-}2}$. The particular situation shown in Fig. 3 happens to correspond to the example scenario of Fig. 2A, in which the CCGI database 102_1 of SRNC 26_1 has the most current cell information for cell $28_{2\text{-}1}$ (i.e., has the same cell information for cell $28_{2\text{-}1}$ as does CCGI database 102_2). In such event, the response message 112_3 (known as the radio link setup response message) need not include the cell information for cell $28_{2\text{-}1}$, but rather includes the cell identifier for cell $28_{2\text{-}1}$. Moreover, since the scenario of Fig. 3 concerns a radio link setup procedure, the response message 112_3 includes information regarding the resources allocated by DRNC 26_2 (depicted as "RESOURCE INFO" in Fig. 3) Such resources can include, for example, the DL codes (one or more pairs of DL channelization code and scrambling code), among other items. Of course, the manifestation of the request message as a radio link setup need not follow the example scenario of Fig. 2A, but could instead follow other scenarios such as the scenarios of one of Fig. 2B - Fig2D, for example.

The scenario of Fig. 4 resembles that of Fig. 3, but differs in that the request message takes the form of a radio link addition request message 110_4 rather than a radio link setup request message. A radio link addition request message, which starts a radio link addition procedure, is employed when the SRNC desires to establish another leg of a connection with a user equipment unit (UE) in a cell controlled by the DRNC, the SRNC already having a least one radio link controlled by the DRNC extant (e.g., at least one radio link using resources in a cell controlled by the DRNC already exists). This is illustrated in Fig. 4 by inclusion of user equipment unit (UE) 30(4), which is moving into cell $28_{2\text{-}3}$ subsequent to the establishment of a connection leg with user equipment unit (UE) 30 via cell $28_{2\text{-}1}$. Therefore, concerning user equipment unit (UE)

30(4), the cell which is the subject of the radio link addition request message 110_4 is cell $28_{2\text{-}3}$. The situation shown in Fig. 4 corresponds more closely to that of the general case of Fig. 2B in which the CCGI database 102_1 of SRNC 26_1 does not have an updated version of the cell information for cell $28_{2\text{-}3}$. This is reflected by the fact that the value of cell configuration generation index (CCGI) for cell $28_{2\text{-}3}$ as stored in the CCGI database 102_1 and included in the radio link addition request message 110_4 has the value "A", rather than the updated value of "B" as stored in the CCGI database 102_2. Accordingly, the radio link addition response message 112_3 of Fig. 4 includes, in addition to the list of resources allocated for the added connection leg, the cell identifier for cell $28_{2\text{-}3}$, the cell configuration generation index (CCGI) associated with and representing the cell information deemed current by DRNC 26_2, and the cell information deemed current by DRNC 26_2 (depicted as [CELL INFO[$28_{2\text{-}3}$] in Fig. 4). The UE connection manager 100_4 of SRNC 26_1 can then update its entry in CCGI database 102_1 for cell $28_{2\text{-}3}$, storing the updated cell configuration generation index (CCGI) value of B in the second field and the current/updated cell information for cell $28_{2\text{-}3}$ in the third field. Of course, as mentioned above, a radio link addition response message can follow any of the scenarios above described in addition to the example scenario of Fig. 2B, such as the scenarios of Fig. 2A or Fig. 2C, for example.

Fig. 5 shows the generic request message request message taking the form of a cell information retrieval request message 110_5. In this context, the manager 100_1 of SRNC 26_1 takes the form of dynamic cell info database manager $100_{5\text{-}1}$, while the manager 100_2 of DRNC 26_2 takes the form of cell info database manager $100_{5\text{-}2}$. The scenario of Fig. 5 permits a RNC such as a SRNC to retrieve cell information for a certain cell in another RNC (e.g., a DRNC) without requesting any resources in the cell.

Thus, as illustrated by Fig. 3 and Fig. 4, respectively, the response message can be of the nature of a radio link setup response message or a radio link addition response message. The request and response messages of the present invention are not, however, limited to or necessarily confined to resource allocation, as the request message can instead take the form of a status or update request or the like for ascertaining the actual current cell information for the specified cell in the example manner of Fig. 5.

In example modes of the invention described above, the cell information includes a set of cell information parameters characterizing the specified cell served by

a base station controlled by the second control node. In other modes of the invention described in more detail below, the cell information can additionally or optionally include a set of cell information parameters which characterizes at least one cell which neighbors the specified cell. Preferably, the cell information includes a set of cell information parameters for all of the cells which neighbor the specified cell.

Fig. 6 shows a scenario in which the request message 110_6 includes, in addition to the cell identifier and cell configuration generation index (CCGI) for a specified cell (e.g., cell 28_{2-1}), a list of neighboring cells for the specified cell. In the embodiment shown in Fig. 6, the CCGI databases 102_{6-1} and 102_{6-2} additionally maintain, for each cell entered in the database, a list of neighboring cells (shown as the fourth field in each row of the databases). The master or most current list of neighboring cells controlled by DRNC 26_2 is maintained by the CCGI database 102_{6-2}. In the context of the illustration of Fig. 6, cell 28_{2-1} has cell 28_{2-2} and cell 28_{2-3} as neighboring cells which are controlled by DRNC 26_2. In preparing the request message 110_6, the list of neighboring cells for the specified cell is taken from a fourth field for the row of cell 28_{2-1} in the CCGI database 102_{6-1}. The manager 100_6 of the SRNC 26_1 further searches the CCGI database 102_{6-1} to obtain, for each of the neighboring cells listed in the fourth field, a cell configuration generation index (CCGI) value for such neighboring cells for inclusion in the request message 110_6.

In the particular situation shown in Fig. 6, the cell information contained in CCGI database 102_{6-1} for the specified cell (i.e., cell 28_{2-1}) and each of its neighboring cells is current. Therefore, in accordance with the general scenario of Fig. 2A, the response message 112_6 returned by the DRNC 26_2 need not include any cell information for any cell. Rather, the response message 112_6 returned by the DRNC 26_2 bears the cell identifier for the specified cell.

Fig. 6A(1) shows a situation, akin to that of Fig. 2B, in which the cell information contained in CCGI database 102_{6-1} for the specified cell 28_{2-1} is incorrect. Particularly, CCGI database 102_6 contains an out-dated version of cell information for cell 28_{2-1} as represented by CCGI=Y, whereas the CCGI database 102_{6-2} maintained by DRNC 26_2 has cell information for cell 28_{2-1} represented by CCGI=Z. However, the cell information maintained for the cells which are neighboring cells of cell 28_{2-1} (e.g., cell 28_{2-2} and cell 28_{2-3} are current). Accordingly, in the Fig. 6A(1) scenario, the

response message $112_{6A(1)}$ includes the cell identifier for cell $28_{2\text{-}1}$, the cell configuration generation index (CCGI) associated with and representing the cell information deemed current by DRNC 26_2, and the cell information deemed current by DRNC 26_2 (depicted as [CELL INFO[$28_{2\text{-}1}$] in Fig. 6A(1)). No cell information for the neighboring cells need be included in the response message $112_{6A(1)}$. The manager $100_{6\text{-}2}$ of SRNC 26_1 can then update its entry in CCGI database $102_{6\text{-}1}$ for cell $28_{2\text{-}1}$, storing the updated cell configuration generation index (CCGI) value of Z in the second field and the current/updated cell information for cell $28_{2\text{-}1}$ in the third field.

Fig. 6A(2) shows a situation in which the cell information contained in CCGI database $102_{6\text{-}1}$ for the specified cell $28_{2\text{-}1}$ is correct, but the cell information for cell $28_{2\text{-}2}$ is not current. The response message $112_{6A(2)}$ includes the cell identifier for the cell for which CCGI database $102_{6\text{-}1}$ needs updating (e.g., cell $28_{2\text{-}2}$); the cell configuration generation index (CCGI) associated with and representing the cell information deemed current by DRNC 26_2 for cell $28_{2\text{-}2}$; and, the cell information deemed current by DRNC 26_2 for cell $28_{2\text{-}2}$ (depicted as [CELL INFO[$28_{2\text{-}2}$] in Fig. 6A(2)). The manager $100_{6\text{-}2}$ of SRNC 26_1 can then update its entry in CCGI database $102_{6\text{-}1}$ for cell $28_{2\text{-}2}$, storing the updated cell configuration generation index (CCGI) value of B in the second field and the current/updated cell information for cell $28_{2\text{-}2}$ in the third field.

A response message having a format such as the response message $112_{6A(2)}$ of the Fig. 6A(2) signifies that the cell $28_{2\text{-}2}$ is still a valid neighboring cell, but that the actual configuration does not correspond to the cell configuration generation index (CCGI) received in the request message. This could mean either: (1) the cell configuration generation index (CCGI) has changed for the neighboring cell (in the case that the cell identifier is included in the request, or (2) the cell is a new neighboring cell (in the case that the cell identifier is not included in the request).

From the foregoing it can be understood that other scenarios are also encompassed within the present invention, such as a scenario in which the response message must include current cell information and corresponding cell configuration generation index (CCGI) values for plural neighboring cells, or a scenario in which the response message must include current cell information and corresponding cell

configuration generation index (CCGI) values for both the specified cell and one or more neighboring cells.

Fig. 6B(1) shows a scenario in which the a request message 110_{6B} includes an incomplete list of neighboring cells. In the Fig. 6B(1) scenario, the CCGI database 102_{6-1} SRNC 26_1 does not yet know that cell 28_{2-3} is a neighboring cell for cell 28_{2-1}. The request message $110_{6B(1)}$ of Fig. 6B(1) therefore includes an incomplete list of neighboring cells. Upon receipt, the manager 100_2 of DRNC 26_2 notes the incomplete list of neighboring cells in the request message $110_{6B(1)}$, and accordingly prepares a response message $112_{6B(1)}$ for the request message $110_{6B(1)}$ that concerned specified cell 28_{2-1}. The response message $112_{6B(1)}$ includes a cell identifier for the cell 28_{2-3} (the cell whose neighboring status was unknown to SRNC 26_1); as well as the cell information deemed current by DRNC 26_2 for cell 28_{2-3} and the cell configuration generation index (CCGI) representative thereof (CCGI=5).

Fig. 6B(2) shows a situation more egregious than that of Fig. 6B(1), in which the the CCGI database 102_{6-1} SRNC 26_1 does not know any of the neighbors for cell 28_{2-1}. In a manner understood from Fig. 6B(1) and the foregoing explanation thereof, the response message $112_{6B(2)}$ of Fig. 6B(2) supplies the CCGI database 102_{6-1} of Fig. 6B(2) with the cell information and cell configuration generation indices (CCGI) for all cells controlled by DRNC 26_2 which neighbor cell 28_{2-1}. In essence, this amounts to the DRNC 26_2 providing a list of known neighboring cells and cell information for those neighboring cells to the SRNC 26_1.

Fig. 6C shows a situation in which the CCGI database 102_{6-1} SRNC 26_1 incorrectly assumes that cell 28_{2-4} is a neighboring cell for cell 28_{2-1}. In such case, the response message 112_{6C} includes a cell identifier for the cell erroneously deemed by SRNC 26_1 to be a neighbor (e.g., a cell identifier for cell 28_{2-4}), and an indication that such cell is not a neighbor cell (e.g., a NOT NEIGHBOR FLAG).

For the scenarios of Fig. 6, Fig. 6A(1), Fig. 6A(2), Fig. 6B(1), Fig. 6B(2), and Fig. 6C, the response messages can optionally include cell identifiers of the valid cells for which no updating or addition is required (as, e.g., a confirmation that those cells are still valid and that the cell information therefor as stored at the SRNC 26_1 is still viable [e.g., current]). Moreover, for any of the scenarios of Fig. 6, Fig. 6A(1), Fig.

6A(2), Fig. 6B(1), Fig. 6B(2), and Fig. 6C, the request messages can take the form of any one of the example messages previously described, such as (for example) a radio link setup request message, a radio link addition request message; a cell information retrieval request message, etc.

In conjunction with the foregoing, a radio access network can have a radio network controller having access to a cell configuration generation index (CCGI) for each cell controlled thereby and that is defined as a neighboring cell to any other cell in the radio access network. The cell configuration generation index (CCGI) thus, in one of its aspects, represents a set of cell configuration parameters to be communicated between radio network control nodes

The scenarios and procedures described above can be used for various purposes. For example, the scenario of Fig. 5 with its cell information retrieval procedure can be used (but need not be exclusively used) for configuration information needed for positioning purposes (e.g., when determining the position of a user equipment unit (UE)). The scenarios described above are merely non-limiting examples and are not intended to be exhaustive. It should further be understood that for many of the messages described herein that other parameters can be included; the illustrated parameters are those pertinent to the present invention but not necessarily comprehensive of types of parameters that may be included for other purposes.

As apparent from the foregoing, cell information for a specific cell need be transmitted over the Iur interface only when changed. Advantageously, the present invention reduces data volumes transferred between control nodes of a radio access network (e.g., between SRNC 26_1 and DRNC 26_2) on such occasions as, for examaple, establishing resources in a cell controlled by the DRNC 26_2. The invention therefore also beneficially reduces signaling delay between the radio network control nodes.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.